Implementation of simulation training in the Intensive Care Units (ICU) during the COVID-19 pandemic: A scoping review

Mise en place des formations par simulation dans les Unités de Soins Intensifs (USI) pendant la pandémie de COVID-19: Un examen de la portée

Hajer Nouira[1,2], Oussama Jaouad[1,2], Islem Ouanes[2,3], Maissa Jrad[1,2], Soumaya Chtioui[1,2], Rim Gharbi[1,2], Mohamed Fekih Hassen[1,2], Habiba Ben Sik Ali[1,2], Souheil Elatrous[1,2]

1. Department of Intensive Care, Taher Sfar Hospital, Mahdia, Tunisia
2. University of Monastir, Faculty of Medicine Monastir, Tunisia
3. Department of Intensive Care, El Yosr International Clinic, Sousse, Tunisia

Abstract

Introduction: In response to the important influx of critically ill patients as well as resources limitation, simulation would be a tool ensuring the continuum of medical training.

Aim: To assess the impact of simulation training on both education and performance related to protocol development during COVID-19 pandemic, in critical care.

Methods: This scoping review was written in accordance with the PRISMA Guideline. Data sources and studies were identified by searching "MEDLINE", "Cochrane library" databases and "Clinical trial.gov". Study inclusion adhered to the PICO criteria: Population, Intervention, Comparison, and Outcomes. The Kirkpatrick Model, is a tool for evaluating the level of impact of training results according to four levels

Results: The search algorithm yielded sixteen articles of which eight were meeting criteria for inclusion and finally seven were available. The number of participants ranged from 12 to 108 with a median of 61 (IQR: 8-76). The length of intervention ranged from 12 min to three hours with a median of 38 min (IQR: 12-135). Studies reported that incorporating simulation yields a more pronounced impact compared to theoretical and clinical training alone in enhancing knowledge and confidence. Regarding the role of simulation in protocol development, results have shown that in the pre-test, all the participants failed donning and doffing Personal Protective Equipment (PPE), the mean cognitive load was high (7.43±0.9 points) and the performance was low (2.5±0.8) while in the post-test, 100% of participants were successful in donning the PPE, the mean of the cognitive load decreased (4.1±1.4 points), and the performance substantially increased (7.9±1.1). In addition, five studies showed behavioral changes after training and thus the simulation reached Kirkpatrick level three.

Conclusion: Results supported the impact of simulation, in critical care, as an effective method to enhance knowledge and confidence, and to improve protocol development during pandemics such as COVID-19.

Key words: Simulation Training, Critical Care, Health Education, COVID-19, Guideline Adherence.

Résumé

Introduction: Face à l'important afflux de patients en réanimation ainsi qu'à la limitation des ressources, la simulation serait un outil pédagogique garantissant la continuité de la formation médicale.

Objectif : Evaluer l'impact de la formation par simulation en réanimation sur l'éducation et les performances liées au développement de protocoles pendant la pandémie COVID-19.

Méthodes: Cette revue de la portée a été rédigée conformément à la directive PRISMA. Les études ont été identifiées en effectuant des recherches dans "MEDLINE", "Cochrane library" et "Clinical trial.gov. Le modèle de Kirkpatrick est un outil permettant d'évaluer le niveau de l'impact des résultats de la formation selon quatre niveaux.

Résultats: L'algorithme de recherche a fourni seize articles, dont huit ont satisfait les critères d'inclusion et finalement sept étaient disponibles. Le nombre de participants variait de 12 à 108, avec une médiane de 61 (IQR : 8-76). La durée de l'intervention variait de 12 minutes à trois heures, avec une médiane de 38 minutes (IQR : 12-135). Les études ont rapporté que la simulation avait un impact plus important que la formation théorique seule pour améliorer les connaissances et la confiance. Pour le développement de protocoles, les résultats ont montré qu'en pré-test, tous les participants échouaient à enfiler et à retirer l'équipement de protection individuelle (EPI), la charge cognitive moyenne était élevée (7,43±0,9 points) et la performance était faible (2,5±0,8), tandisqu'en post-test, 100% des participants réussissaient à enfiler l'EPI, la charge cognitive moyenne diminuait (4,1±1,4 points) et la performance augmentait (7,9±1,1). Cinq études ont montré des changements de comportement après la formation, ce qui a permis d'atteindre le niveau trois du modèle de Kirkpatrick.

Conclusion: Les résultats ont soutenu l'impact de la simulation en réanimation en tant que méthode efficace pour améliorer les connaissances, la confiance, et le développement de protocoles lors de pandémies telles que la COVID-19.

Mots clés: Formation par simulation, Soins de réanimation, Education pour la santé, COVID-19, Adhésion aux directives.

Correspondance
Hajer Nouira
Department of Intensive Care, Taher Sfar Hospital, Mahdia. University of Monastir, Faculty of Medicine Monastir, Tunisia
Email: nouirahajer@gmail.com

LA TUNISIE MEDICALE-2024; Vol 102 (08): 433-439 DOI: 10.62438/tunismed.v102i8.4972

Introduction

Simulation has been defined as a material, device and/or environment that replicate some or nearly all of an aspect of clinical situation (1). In the past, the value of this approach has been also recognized to improve preparedness in an outbreak (2). It is a pedagogic tool that has been emerged to ensure the continuum of medical training whilst attempting to avoid the risk of contamination and could have an integral role especially during a pandemic. The French National Authority for Health (HAS) has published in 2012 a guide practices in health simulation (in French). This initiative would facilitate the application of this challenging pedagogical tool within well-defined rules (3). The Coronavirus pandemic has created the largest challenge to health systems joining a list of other pandemics that have tested the resilience and capacity of healthcare systems worldwide (4, 5). In response to ongoing concerns regarding the important influx of hospitalized and critically ill patients, healthcare workershave grappled with the need for rapid and efficient preparedness (6). They have adopted several strategies including expanding intensive care unit bed capacities, training redeployed practitioners, addressing knowledge gaps as well as establishing infection control and mitigation protocols. Along side the challenge faced on health care systems to cope with the burden COVID-19, the shut down of academic institutions have taken a profound impact on medical education (7). In this scoping review, we aimed to assess the impact of simulation training on both education and performance related to protocol development during COVID-19 pandemic, in critical care.

Methods

This is a scoping review of articles on the Simulation training amidst the COVID-19 pandemic, in Critical Care. This review was written in accordance with the PRISMA 2020 Guideline (8). Data sources and studies were identified by searching “MEDLINE”, “Cochrane library” data bases and “Clinical trial.gov”. The last search was run on 01 May 2021. It was conducted using the following search strategies:

MEDLINE: ("Critical Care"[Mesh] OR "Intensive Care Units"[Mesh]) AND ("Simulation Training"[Mesh]) AND ("COVID-19"[Mesh] OR "SARS-CoV-2"[Mesh] OR "Coronavirus"[Mesh]);

Cochrane: (simulation) AND (covid19 OR coronavirus OR SARS cov2) AND (critical care OR intensive care);

Clinical trial.gov: (COVID-19 | simulation training).

Study inclusion adhered to the PICO criteria: Population, Intervention, Comparison, and Outcomes. Population included health care providers (physicians, residents, nurses, paramedic’s and therapists), medical students and other paramedical specialties such as nursing and midwifery students. Intervention included any application of simulation during the COVID-19 era, in Critical Care. For the Comparison, we aimed to investigate studies comparing participant knowledge and/or performance between intervention and control groups. Comparisons between pre- and post-intervention outcomes were also accepted. Outcomes investigated the impact of such interventions on education and on performance related to protocol development during COVID-19 pandemic.

The results of this literature search were selected and limited to articles published in English; we excluded also letters to the editor, commentaries and editorials. Two different authors independently selected and retrieved the outcomes. The Kirkpatrick Model (9), first developed by Donald Kirkpatrick in 1959, is a tool for evaluating the effectiveness of a training program. The model stratifies the level of impact of training results according to four levels: performance and patient outcomes (level 4), behavioral change after training (level 3), individual learning (level 2), and participants’ reactions to training (level 1). For each included article, the bibliometric characteristics were collected and methodological information were summarized in tabular form. Moreover, the main results and the Kirkpatrick level investigated were sorted and we performed structured synthesis of the available data in three thematic axes which were expanded in the discussion section (Impact of simulation oneducation, on performance related to protocol development and challenges encountered with implementing simulation for COVID-19).

Results

The search algorithm yielded sixteen articles from “MEDLINE” and “Cochrane library”. No results for the search on “Clinical trial.gov”. Based on the language (English) and on the type of article, 13 articles were selected, of which eight were meeting criteria for inclusion and finally seven (10-16) were available. Figure n°1 summarizes the study selection process and exclusion reasons.

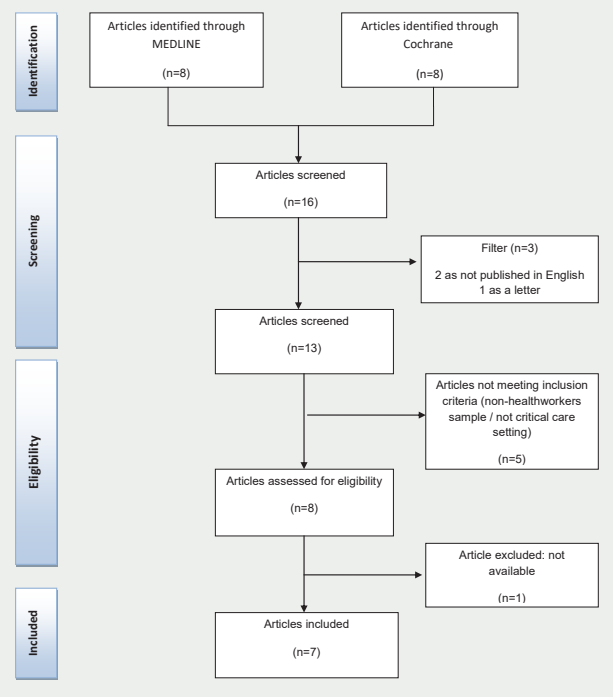

Figure 1. Flow chart of the study selection process

Bibliometric characteristics of the articles included in this scoping review are detailed in Table 1. Among the seven articles, five were published during 2020. The included articles were three Randomized Controlled Trials and four Journal articles. Studies were carried out in USA (3 studies), Australia (2 studies), Austria (1study) and Jordan (1 study). The included number of participants ranged from 12 to 108 with a median of 61 (interquartile range: 38-76).

Table 1. Bibliometric characteristics of the included articles on simulation training incritical care during The COVID-19 pandemic

Author, year (Ref)	Specialty of the first author	Type of publication	Publication Journal	Country
Loai I. Tawalbeh, 2020 **(10)**	Nurse	Randomized Controlled Trial	International Journal of Africa Nursing Sciences	Jordan
Yuriditsky E, 2021 **(11)**	Cardiology	Journal Article	Journal of Critical Care	USA
Prasad N, 2020 **(12)**	Obstetrics &Gynaecology	Journal Article	Journal of Interprofessional Care	Australia
Díaz-Guio DA, 2020 **(13)**	Intensive care	Journal Article	Le Infezioni In Medicina	USA
Fong S, 2020 **(14)**	Anesthesiology	Randomized Controlled Trial	Canadian Journal of Anaesthesia	USA
Kienbacher CL, 2021 **(15)**	Emergency Medicine	Randomized Controlled Trial	Resuscitation	Austria
Begley JL, 2020 **(16)**	Intensive care	Journal Article	Anaesthesia	Australia

USA: United States of America

In addition to physicians, two studies included nurses, one study included midwifery students and one study included nursing students. Interventions used were diverse (Table 2). The length of intervention ranged from 12 min to three hours with a median of 38 min (interquartile range: 12-135).

All the three studies investigating the impact of simulation on education reported a significant impact of simulation on enhancing knowledge and confidence (Table 3). Regarding the role of simulation in COVID-19 specific protocol development, Díaz-Guio DA et al. have shown that in the pre-test, all the participants failed donning and doffing Personal Protective Equipment (PPE), the mean cognitive load was high (7.43±0.9 points) and the performance was low (2.5±0.8) while in the post-test, 100% of participants were successful in donning the PPE, the mean of the cognitive load decreased (4.1±1.4 points), and the performance substantially increased (7.9±1.1). Two simulation studies focused on airways management in patients with COVID-19, founding that the use of the aerosol box increased time to intubation and presented subsequently a higher risk of hypoxia. Kienbacher CL et al. examined the effects of PPE on the quality of Cardio Pulmonary Resuscitation (CPR). This randomised controlled trial has revealed that PPE, including masks with and without valves, does not impair CPR quality (mean compression depth was 56 mm (SD=3.7) using no additional PPE (control), 56 mm (SD=3.6) using a FFP2 mask with a valve and 56 mm (SD=3.6) using a FFP2 mask (without a valve). In addition, five studies showed behavioral changes after training and thus the simulation reached Kirkpatrick level 3. Two studies assessed Kirkpatrick level 2. The impact of training on patient outcomes has not been assessed in any study.

Discussion

This scoping review has been carried out to assess the impact of simulation on both education and performance related to protocol development during COVID-19 pandemic, in critical care. In fact, an array of simulation techniques can be leveraged for usually two purposes: education and assessment (17). The included studies showed that simulation training improved participants' knowledge, confidence and comfort in the management of ICU patients. These results were also echoed in several randomized controlled trials which asserted that simulation was superior regarding its effect on knowledge compared with traditional training (18, 19). Moreover, Robyn P. et al published a systematic review (20) on simulation in nurse education, in which, all included studies reported a significant impact of simulation as a method to enhance knowledge, confidence and critical thinking ability. These results could be explained by the safe learning environment that offers the simulation for trainees, allowing a move away from simple to complex tasks and providing psychological support (21).

The current context of the coronavirus pandemic has undeniably led to an important disruption of education systems in order to slow down the spread of the virus. These facts highlighted the importance of implementing new technologies as adaptive training including e-learning, tele-conferences and webinars (22). In this review, Prasad N et al (12) reported that online simulation delivered in an e-learning format may be beneficial and can be applicated. These findings expand on those of a recent scoping review carried out by Dedeilia A. et al (23) who underlined the importance of this technology as a useful tool for minimizing the educational gap during the COVID-19 pandemic. This tool could also be needed for redeployment of health professionals due to the increasing number of patients requiring hospitalization in ICUs. Yuriditsky E et al (11) has shown that simulation-based training improved knowledge in the management of ICU patients for participants who were going to be deployed to COVID-19 intensive care. In the literature, there has been considerable interest in the integral role of simulation in cross-skilling healthcare workers in the past, during the Influenza and Severe Acute Respiratory Syndrome (SARS) pandemics (24).

The pandemic has led to dramatic consequences for human health and therefore, it has required an urgent need of innovating new protected protocols and reconciling existing guidelines such us protocols for intubation, donning and doffing of PPE, cardiac arrest protocol and proning protocol. The present study pointed at the significant impact of simulation on the improvement of participants' performance and safety in donning and doffing PPE.

Table 2. Theme and Methodology of included studies on simulation training in critical care during the COVID-19 pandemic

Study	theme	Design and setting	Participants	Intervention	Instruments / Outcomemeasures	Primary outcome
			Education			
Loai I. Tawalbeh, (2020) **(10)**	Critical care skills	A randomized controlled Trial (pre-test-post-test) In School of Nursing From September to December 2019.	Nursing student who registered in critical care course for the first time at the faculty of nursing.	The experimental group attended 9 simulation scenarios, theoretical and clinical training in hospital while the control group attended only the theoretical training in hospital. Each scenario lasted for two hours.	A structured questionnaire Knowledge exam and self-confidence scale.	The mean of knowledge and confidence.
Yuriditsky E *et al.* (2021) **(11)**	Cross-skilling	A prospective study At the Veterans Affairs New York Harbor Healthcare System simulation center. Between March and April 2020.	Non-intensive care trained faculty, fellows, chief residents, nurse practitioners, and physician assistants who were going to be deployed to COVID-19 intensive care.	A 3 h simulation-based session focused on management of shock, mechanical ventilation, acute respiratory distress syndrome, and critical care ultra sound.	A five-point Likert scale was used to assess the program and specific topics.	The Improvement of knowledge in the management of ICU patients.
Prasad N *et al.* (2020) **(12)**	Perinatal emergency	A prospective study Between February 2020 and May 2020.	Monash University fourth-year medical students and final year midwifery.	The online ONE-Sim workshop was run virtually using "Zoom" by a team of four facilitators, via video conference. Initial briefing (5 min) / Scenarios (20 min): Three clinical emergency scenarios/ Debrief (40 min)	**©2020 Zoom video Communications** The ONE-Sim program A survey was conducted to explore the impact of the e-learning platform on students' overall learning.	The impact of the e-learning platform on students' overall learning experience.
			COVID-19 specific protocol development			
Díaz-Guio DA *et al.* (2020) **(13)**	PPE*	A prospective, before-and-after design In a clinical simulation certified center in Colombia. Between February and March 2020	Physicians, nurses and respiratory therapists from the emergency room and intensive care unit.	A simulation- based educational intervention/ two cases related to COVID-19. A workshop for donning and doffing of personal PPE.	The 9-point Paas scale to determine the cognitive load. CDC donning and doffing checklist. Evaluation of performance maked by the reviewer with a Paas scale	The cognitive load and the performance before and after the intervention.
Fong S *et al*, (2020) **(14)**	Airway management	A randomized crossover trial At the simulation centre on the University of Alberta campus.	Being either a resident physician or staff Physician in anesthesiology, critical care, or emergency medicine.	Four airway simulations with and without the aerosol box (normal, pharyngeal swelling, cervical spine rigidity, and tongue edema). Each participant intubated the mannequin in eight consecutive simulations. Intervention: intubation box/ Control: no intubation box	The SimMan 3G mannequin (Laerdal Medical Canada) The participant's order of scenarios was randomized using the online software.	The impact of the aerosol box on intubation time.
Kienbacher CL *et al*, (2021) **(15)**	PPE and Cardio-pulmonary resuscitation	Randomised controlled non-inferiority triple-crossover study.	Emergency medical service providers	Two teams performed 12 min of Basic Life Support (BLS) on a manikin after climbing 3 flights of stairs. Three scenarios: Without PPE, with PPE including a FFP 2 mask with valve, and with PPE including an FFP2 mask without valve.	The European Resuscitation Council's (ERC) current guidelines. The manikin (qCPRResusciAnn, Laerdal1, Norway).	Quality of chest compressions, measured by the mean depth of chest compressions.
Begley JL *et al.* (2020) **(16)**	Airway management	A prospective, crossover study In a negative-pressure room in the ICU* at Cabrini Hospital in Melbourne, Australia.	Anesthetists	Three intubations were performed by each participant; one with no aerosol box and one with each of the aerosol boxes (36 Intubations in total).	The 'early-generation' box and The 'latest-generation' box SAS guidelines A simulated vital-sign monitor (SimMon version 1.8.6) An Airsim Advance Crico was used as the airway manikin	Intubation time.

PPE: Personal Protective Equipment **ICU**: Intensive Care Unit

Table 3. Main results of included articles on simulation training in critical care during the COVID-19 pandemic

Study	Sample size	Main Results	Impact of simulation	Kirkpatrick level
		Education		
Loai I. Tawalbeh, 2020 **(10)**	76	A paired t-test indicated that mean knowledge and confidence regarding implementing critical careskills were significantly higher p <0.001 in the post-test than that in the pre-test, in both the experimental and the control group. Independent t test revealed that the students in the experimental group scored significantly higher p < 0.001 than control group in both knowledge and confidence.	Adding simulation has a more significant effect than theoretical and clinical training in improving nursing students' knowledge and confidence	3
Yuriditsky E *et al*.(2021) **(11)**	108	104/108 responders (96%) felt training either significantly or some what improved their knowledge in the management of ICU patients.	Simulation-based training improved provider comfort in the management of critically ill patients with COVID-19.	3
Prasad N *et al*.(2020) **(12)**	71	Based on the researchers' observation, students reacted positively to the online simulation and interacted collaboratively with each other during the video conference.	Interprofessional education delivered in an e-learning format can be useful and meaningful, and may be utilized across a number of specialties.	3
		COVID-19 Specific Protocol Development		
Díaz-Guio DA *et al*.(2020) **(13)**	61	In the pre-test, all the participants failed donning and doffing PPE. The mean cognitive load was high (7.43±0.9 points), and the performance very low (2.5±0.8). In the post-test, 100% of participants were successful in donning the PPE and 94.8% in doffing. The mean of the cognitive load was low (4.1±1.4 points), and the performance was high (7.9±1.1).	Donning and doffing PPE is critical and may be changed significantly by active training with clinical simulation in terms of performance and decreased cognitive load	3
Fong S, 2020 **(14)**	38	Mean (standard deviation [SD]) time to intubation overall with the box was 30.9 (23.0) sec, whilethe time to intubation without the box was 25.1 (12.2) sec (mean difference, 5.8; 95% confidence interval [CI], -2.9 to 14.5).	This mannequin-based simulation study has shown that the use of the aerosol box increased the time to intubation in some contexts	2
IKienbacher CL, 2021 **(15)**	48	The mean compression depth was 56 (SD 3.7) mm using no additional PPE (control), 56 (3.6) mm using a FFP2 mask with a valve and 56 (3.6) mm using a FFP2 mask without a valve. There was a mild increase in both systolic blood pressure (+6 to 10 mmHg) and in heart rate (+15 to 23 bpm) after CPR, but this was true both for the control group, and both types of masks.	PPE including masks with and without expiration valve is safe for use without concerns regarding the impairmentof CPR quality	3
Begley JL *et al*.(2020) **(16)**	12	Intubation time with no aerosol box was significantly shorter than with the early-generation box (median (IQR [range]) 42.9 (32.9–46.9 [30.9–57.6])s vs. 82.1 (45.1–98.3 [30.8–180.0])s p = 0.002) and the latest-generation box (52.4 (43.1–70.3 [35.7–169.2])s, p= 0.008).	Aerosol boxes may increase intubation times and thus expose patients to the risk of hypoxia.	2

ICU: Intensive Care Unit **PPE**: Personal Protective Equipment **FFP2**: Filtering Face Piece **IQR**: InterQuartile Range **CPR**: Cardio Pulmonary Resuscitation

Indeed, the use of PPE is a lifesaving procedure. However, we should remember that there is an important threat related to viral exposure in doffing the PPE and thus, a high cognitive load would be generated. Moreover, the airway management of patients with COVID-19 present a high-risk situation not only for healthcare workers but also for the patient who is already susceptible to rapid desaturation (25). For these reasons, before the practice of a new protocol in real-life, we should ensure safety, assess efficacy, identify misconceptions and familiarize staff with this protocol. Two studies (14, 16) in this scoping review focused on the impact of using aerosol boxes for intubation. The authors demonstrated that aerosol boxes increase intubation times and may expose staff to an elevated risk by causing breaches of PPE. Thus, simulation serves for a safe tool with iterative and various drills allowing further revisions, assessing performance, mitigating error as well as decreasing cognitive loads (26). The question then is what are the difficulties and obstacles encountered in implementing simulations during the COVID-19 pandemic? Firstly, participants' safety and social distancing present a major area of concern.Prasad N et al implemented in the included study (12) an e-learning platform to avoid close gatherings of participants.Yuriditsky E (11) et al devided the experimental group of students (38) into three groups, 12-13 students per group. In the literature, the tele simulation and the limited number of groups were also implemented as strategies to bridge this barrier (23, 27). Secondly, shortage of PPE is one of the most important challenges. In fact donning and doffing PPE are frequently needed to be incorporated in simulation training. This concern has resulted in tension between the two necessities: conserving PPE as a limited resource and using it for the scenario. In the authors' experience reported in this systematic review, participants used standard clinical gloves in order to conserve precious PPE supplies (16).

Further considerations were implemented in other studies (26, 27) such as merging various scenarios and keeping their PPE on until the end of simulation. Finally, it is known that educators were composed foremost of healthcare workers in critical care, anesthesiology or emergency medicine. Nevertheless, because of the important influx of patients, they were not usually available to ensure the traditional schedule of simulation in the center, leading to an important shortage of simulation support staff. In response to this concern,many studies, such as the one of Begley JL et al (16), were carried out in-situ.

This scoping review has a number of limitations: First the paucity of available literature is the main one. Further databases would be searched such as "Embase" for further studies but note that it wasn't available in our country. Add to that, we did our research on two large databeses "MEDLINE" and "Cochrane Library" which include large indexed Journals that cover a big part of the English and French literature. We did the search on Clinical Trials.gov as well but no articles were found, it could be explained by the pandemic situation. Then, to broaden the number of included studies, the scarcity of sources constrained us to accept other study designs in addition to randomized controlled trials. However, the justification is that the review outlines a recent topic about simulation, during an ongoing pandemic and there is a need to rapidly cope with the many challenges faced such as the eductional gap. In addition, the use of self-reported outcome measures could restrict quantifying results and thus it could be associated with information bias.

To conclude, in this scoping review, results supported the significant impact of simulation as an effective method to enhance knowledge and confidence, to improve protocol development and to adapt learning pedagogy, in critical care settings, with emerging and re-emerging diseases, particularly pandemics such as COVID-19, H1N1 and others. For that, it was suggested to create a contingency plan for the implementation of simulation programs, with a considerable 'buy-in' from clinicians to improve performing skills during this pandemic. Cooperative means in the faculty are also needed to pave the way for including simulation to be used as main education approach. Finally, it would be of great interest to carry out additional well-designed studies reporting findings on the highest Kirkpatrick levels and making possible to transfer learning to patient outcomes.

Acknowledgment

The authors would like to express their gratitude to Professor Ahmed Ben Abdelaziz, Director of the Research Laboratory LR19SP01 "Measurement and Support for Hospital Performance," for his critical review of this manuscript.

References

1. Cook DA, Hatala R, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011;306(9):978-88.
2. Biddell EA, Vandersall BL, Bailes SA, Estephan SA, Ferrara LA, Nagy KM, et al. Use of simulation to gauge preparedness for Ebola at a free-standing children's hospital. Simul Healthc. 2016;11(2):94-9.
3. Haute Autorite de Sante. [Guide for Good Practice in Health Simulation]. Haute Autorite en Sante. 2012;97.
4. Ben Abdelaziz A, Berkane S, Ben Salem K, Dahdi SA, Mlouki I, Benzarti S et al. Lessons learned from the fight against COVID-19 in the Great Maghreb. Five lessons for better resilience. Tunis Med. 2020; 98 (10):657-63.
5. Ben Abdelaziz A, Berkane S, Ben Salem K, Dahdi SA, Mlouki I, Benzarti S et al. Lessons learned from the fight against COVID-19 in the Great Maghreb. Five lessons for better response. Tunis Med. 2020; 98(12):879-85.
6. Ben Abdelaziz A, Berkane S, Ben Salem K, Dahdi SA, Mlouki I, Benzarti S et al. Lessons learned from the fight against COVID-19 in the Great Maghreb. Five lessons for better preparation. Tunis Med. 2020; 98(8-9):589-95.
7. Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus and COVID-19 pandemic: a review. Int J Surg. 2020; 78:185-193.
8. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. J Clin Epidemiol. 2021;134:103-12.
9. Kirkpatrick D, Kirkpatrick J. Evaluating training programs:In The four levels: Berrett-Koehler Publishers; 2006.
10. Tawalbeh LI. Effect of simulation modules on Jordanian nursing student knowledge and confidence in performing critical care skills: A randomized controlled trial. Int J Afr Nurs Sci. 2020;13:100242.
11. Yuriditsky E, Horowitz JM, Nair S, Kaufman BS. Simulation-based uptraining improves provider comfort in the management of critically ill patients with COVID-19. J Crit Care. 2021;61:14-7.
12. Prasad N, Fernando S, Willey S, Davey K, Kent F, Malhotra A, et al. Online interprofessional simulation for undergraduate health professional students during the COVID-19 pandemic. J Interprof Care. 2020;34(5):706-10.
13. Díaz-Guio DA, Ricardo-Zapata A, Ospina-Velez J, Gómez-Candamil G, Mora-Martinez S, Rodriguez- Morales AJ. Cognitive load and performance of health care professionals in donning and doffing PPE before and after a simulation-based educational intervention and its implications during the COVID-19 pandemic for biosafety. Infez Med. 2020;28 suppl 1:S111-7.
14. Fong S, Li E, Violato E, Reid A, Gu Y. Impact of aerosol box on intubation during COVID-19: a simulation study of normal and difficult airways. Can J Anaesth. 2021;68(4):496-504.
15. Kienbacher CL, Grafeneder J, Tscherny K, Krammel M, Fuhrmann V, Niederer M, et al. The use of personal protection equipment does not impair the quality of cardiopulmonary resuscitation: A prospective triple- cross over randomised controlled non-inferiority trial. Resuscitation. 2021;160:79-83.
16. Begley J, Lavery K, Nickson C, Brewster D. The aerosol box for intubation in coronavirus disease 2019 patients: an in-situ simulation crossover study. Anaesthesia. 2020;75(8):1014-21.
17. Dupre J, Naik V. The role of simulation in high-stakes assessment. BJA education. 2021.
18. Tawalbeh LI. Effect of simulation on the confidence of university nursing students in applying cardiopulmonary assessment skills: A randomized controlled trial. J Nurs Res. 2017;25(4):289-95.
19. Tubaishat A, Tawalbeh LI. Effect of cardiac arrhythmia simulation on nursing students' knowledge acquisition and retention. West J Nurs Res. 2015;37(9):1160-74.
20. Cant RP, Cooper SJ. Simulation-based learning in nurse education: systematic review. J Adv Nurs. 2010;66(1):3-15.
21. So HY, Chen PP, Wong GKC, Chan TTN. Simulation in medical education. J R Coll Physicians Edinb. 2019;49(1):52-7.
22. Reinholz M, French L. Medical education and care in dermatology during the SARS-CoV2 pandemia: challenges and chances. J Eur Acad Dermatol Venereol. 2020;34(5):e214-e6.
23. Dedeilia A, Sotiropoulos MG, Hanrahan JG, Janga D, Dedeilias P, Sideris M. Medical and surgical education challenges and innovations in the COVID-19 era: a systematic review. in vivo. 2020;34(3 suppl):1603-11.
24. Abrahamson SD, Canzian S, Brunet F. Using simulation for training

and to change protocol during the outbreak of severe acute respiratory syndrome. Crit Care. 2005;10(1):1-6.

25. Arentz M, Yim E, Klaff L, Lokhandwala S, Riedo FX, Chong M, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State. JAMA. 2020;323(16):1612-4.11
26. Chaplin T, McColl T, Petrosoniak A, Hall AK. "Building the plane as you fly": Simulation during the COVID-19 pandemic. CJEM. 2020;22(5):576-8.
27. Pan D, Rajwani K. Implementation of Simulation Training During the COVID-19 Pandemic: A New York Hospital Experience. Simul Healthc. 2021;16(1):46.